Supplementary Information

Optimization of a Do-It-Yourself Air Cleaner Design to Reduce Residential Air Pollution Exposure for a Community Experiencing Environmental Injustices

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Section S1. Steps involved in construction of different DIY air cleaner prototypes.

To build a DIY air cleaner, materials and tools including a box fan, filter(s), cardboard, duct tape, a pen/sharpie, and scissor/knife were gathered (Figure S1).

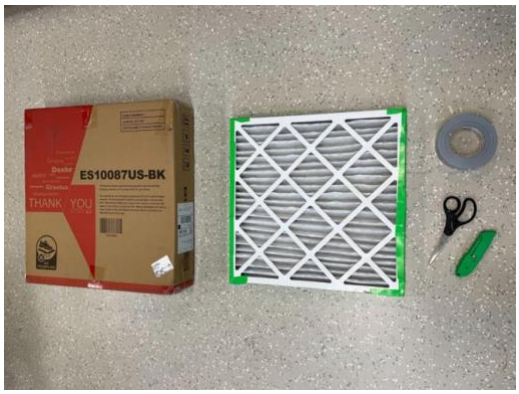

Figure S1. Materials used for construction of different prototypes.

For prototype 1 (P1) as shown in figure S2, all four filters were taped to each other to create a cube shape (the airflow of each filter pointing to the center). An additional 20”x20” piece of cardboard was cut out and attached to the bottom of the cube as the base. All cracks between each filter and the cardboard base were sealed with duct tape. The box fan was then placed on the top of the structure and connected with duct tape. The fan was sealed to the filters with two layers of tape. A shroud was created out of spare cardboard by approximately tracing the front face of the fan and cutting out a circle based on the diameter of the fan blades. A corner of the shroud was also cut off to leave room for the control knob on the fan and the outer edge of the shroud was then sealed to the fan.

Figure S2. The design for prototype 1 (P1) used four 2-inch-thick MERV filters, a box fan, and a cardboard shroud.

To build prototype 2 (Figure S3), two 2-inch-thick filters were taped to each other and then to the fan to create a triangular prism (with the airflow of each filter again pointing to the center). To maintain the balance of the air cleaner, the supplied feet of the box fan were attached to the fan for this design. Two additional triangular pieces of cardboard, with sides measuring 20”x20”x20”, were then attached to the top and bottom of the air cleaner to fill the remaining gaps. All cracks and holes were then sealed with 2 layers of duct tape. A shroud like the one used on P1 was also created and attached to P2.

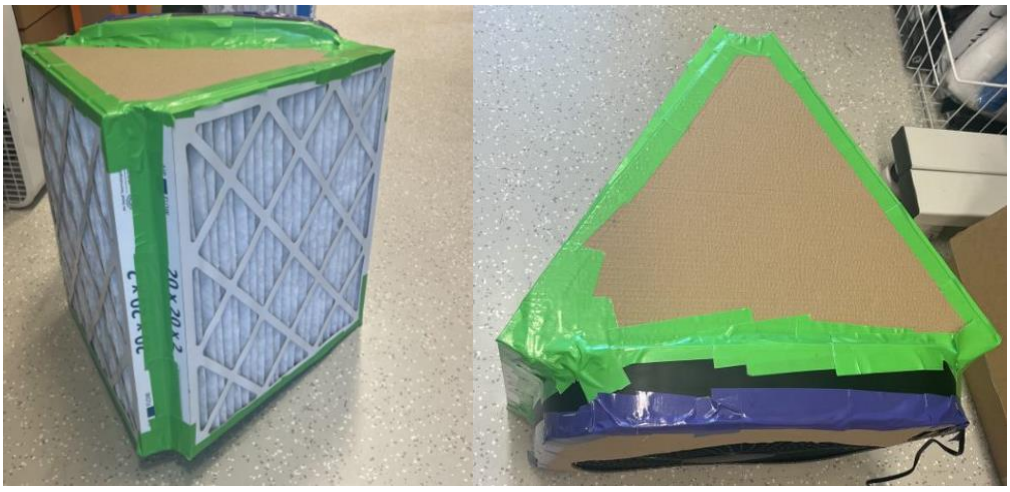

Figure S3. The design for prototype 2 (P2) used two 2-inch-thick MERV filters, a box fan, and a cardboard shroud.

The procedure to build a DIY air cleaner using the DIY box separator was used to create prototypes 3-5 and 7. When using this separator, the provided feet of the box fan were connected to maintain balance of the air cleaner. The DIY box separator was made of four separate pieces of cardboard with dimensions of about 20”x6”. Each piece was individually connected to a corresponding outside edge of the MERV filter with a long piece of duct tape then similarly connected to the box fan. Note that the bottom piece of cardboard was connected between the fan feet and the bottom face of the fan to provide the closest seal. Once attached to the fan and filter, the four pieces of cardboard were then sealed to each other and to the fan and filter, respectively. Any remaining cracks or holes between the cardboard and fan or filter were sealed with additional layers of duct tape. For prototypes 3-5, a shroud was created out of spare cardboard like the shrouds used for prototypes 1 and 2.

Figure S4. The design for prototypes 3-5 (P3-5) used one MERV filter with varying thicknesses, a box fan, and a cardboard shroud. This design used the cardboard DIY box separator between the fan and filter. Note: Prototype 7 (P7) used the same design shown above without the shroud included.

The procedure to build a DIY air cleaner using the fan box separator is similar, though overall requires less time due to less individual pieces of cardboard. This process was used to build prototypes P6, P8, and P9. Once the fan was out of the box it came in, all cracks of the empty box were closed and sealed. On one side, the MERV filter was centered, and the outline traced. A line about 1 inch inside the traced line was drawn to give a ledge for the filter to rest on and cut along the inside line to remove that square. On the other side of the fan box, the fan was placed along the bottom edge of the box, centered from side to side, and traced. Again, another line was drawn about 1 inch inside the traced line and the piece removed. This cut out was kept for prototype 6 to make the shroud. The fan was taped in place on the box and completely sealed against cardboard along all edges with two layers of tape. The filter was similarly taped in place on the other side and completely sealed against the cardboard with duct tape, making sure that the airflow arrow on the filter was pointing into the box and towards the fan.

Figure S5. The design for prototypes 6, 8, and 9 (P6-9) used the fan box as the cardboard separator with a space cut out for the fan and the filter respectively.

For prototype P6, the shroud was then placed on and completely sealed to the front face of the fan. For prototype P9, two activated carbon sheets were cut to the 20”x20” size of the MERV filter and completely attached to the front face of the filter (Figure S6).

Figure S6. The design for prototype 9 (P9) used the same no-shroud design as prototype 8 but includes a layer of activated carbon over the filter.

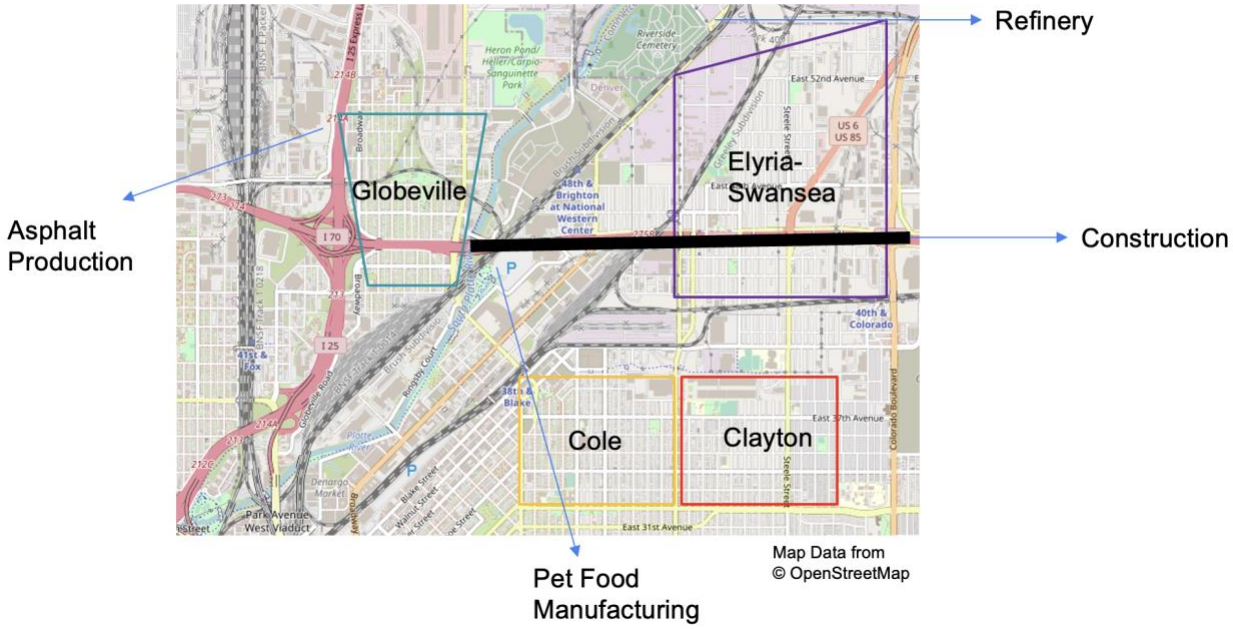

Figure S7. Map of the study area highlighting the four neighborhoods and the major industries in the North Denver area. Map source: OpenStreetMap

Section S2. Noise measurements for single filter prototype.

Preliminary noise measurements were conducted on air cleaner prototype P5 through the phone application “Decibel X”. For the highest speed of the box fan at level 3, the decibels were about 50.1 dBA (adjusted for human hearing); for the medium speed at level 2, the noise level was 46.8 dBA, and lastly, the lowest speed at level 1 gave decibels of 43.7 dBA. Note that these preliminary tests were conducted in a smaller space than the chamber used for CADR testing; this closet-sized room had an ambient noise level of 39.1 dBA.

Table S1. Sociodemographic Data for the Four Neighborhoods Provided by the Colorado Department of Public Health and Environment EnviroScreen.[1]

Percentage of homes that are	Globeville	Elyria-Swansea	Cole	Clayton
Low-Income[ξ]	44	34	57	50
People of Color[Ψ]	73	69	78	62
Housing Burdened[ϒ]	30	34	25	22

[ξ] Median income below 200% of the federal poverty line.
[Ψ] Includes all the population that doesn’t identify as non-Hispanic white.
[ϒ] More than 30% of the household income is dedicated to housing costs like rent or a mortgage.

Table S2. Number of Homes in each of the Four Neighborhoods that used the P9 Prototype during the Fall and Winter Cohorts.

# of homes	Globeville	Elyria-Swansea	Cole	Clayton
Fall 2022	15	38	19	6
Winter 2023	15	54	22	11

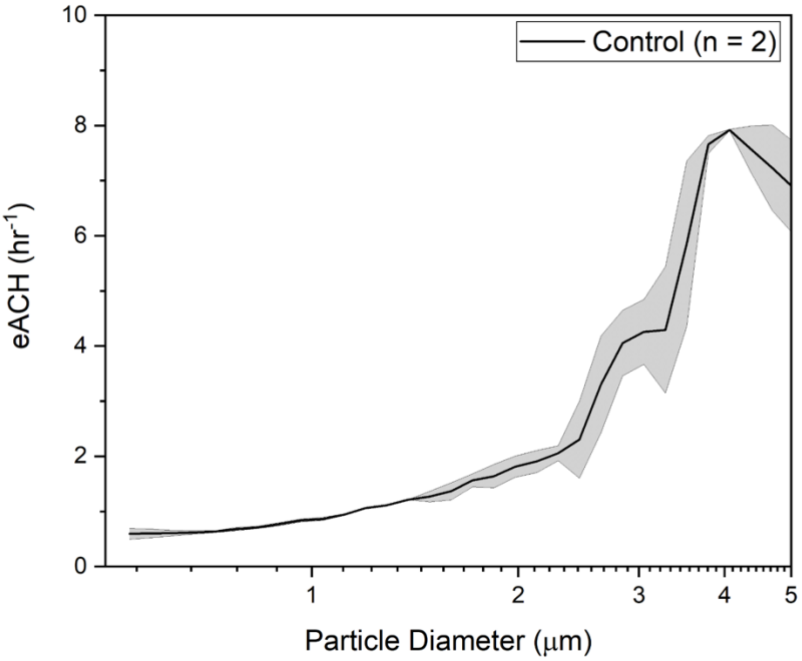

Figure S8. Size resolved PM removal rates due to ventilation and wall deposition mechanisms calculated for control experiments during which no PAC prototype was used during the decay phase of the experiment. The shaded region represents standard deviation.

Table S3. TVOC Removal Rates for Different Prototypes.

Prototype	**TVOC Peak Conc. (ppm)**	**Test Duration (hr)**	**eACH (TVOC)**
Control	0.1	1.7	0.2
P4	3.3	0.3	0.1
P5	0.3	1.3	0.1
P5	0.4	0.6	0.0
P6	1.0	0.3	0.0
P6	3.6	0.2	0.0
P7	0.4	0.3	0.0
P9	0.5	0.7	0.2
P9	0.6	0.9	0.7

References

(1) CDPHE, Colorado Department of Public Health. *Colorado EnviroScreen Environmental Justice Mapping Tool*. https://teeo-cdphe.shinyapps.io/COEnviroScreen_English/ (accessed 2023-04-28).